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ABSTRACT

This booklet (referred to as PD 5686:1969) replaces the 1967 edition by including subsequent recommendations of the International Organization for Standardization (ISO) and the General Conference on Weights and Measures (CGPM). The International System of Units (SI) is described and rules are given for the formation of derived units and decimal multiples and submultiples. The major part of this booklet is a list of the SI units for various physical quantities, the recommended multiples and submultiples of these units, and the non-SI units which may also be used. Further tables give definitions of derived SI units with special names, the value of some imperial units in terms of SI units, and related British Standards publications. (MM)

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the use of SI Units

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The Use of SI Units

Foreword

This booklet was first published in December 1965 to provide a simple account of the units of the metric system and of the way the system has evolved in the past few decades to produce the rational SI metric system now coming into world use.

It was revised in April 1967, and is now again revised to include the provisions of the latest ISO Draft Recommendation No. 1557 for which it is known that there is general international approval. The recommendation also embodies the up-to-date proposals of the General Conference on Weights and Measures (CGPM).

Introduction

The United Kingdom is changing to the metric system at a time when a rationalized system of metric units, the Système International d'Unités (SI), is coming into international use. The SI derives nearly all the quantities needed in all technologies from only six base-units which are arbitrarily defined. This contrasts with the metric systems currently used, in which many additional units (for instance 'calorie' and 'horsepower') are arbitrarily and sometimes differently defined. Relationships between units are thus greatly simplified in the SI, the introduction of which offers existing metric countries a unique opportunity to harmonize their measuring practices.

This opportunity is now being seized. Already some 25 countries have passed or are preparing legislation to make the SI the only legal system of measurement and it is therefore a logical choice for the UK. It involves the use of the newton as the unit of force, which in some sectors may be less well known than the metric technical unit of force, the kilogramme-force.

The use of SI units instead of metric technical units will have little effect on everyday life or trade. The metre and the kilogramme remain the units of linear measure and mass, and the litre, now accepted for most purposes as a special name for the cubic decimetre, will be commonly used as a unit of volume.

The SI is a coherent system of units, and this term should be explained.

A system of units is coherent if the product or quotient of any two unit quantities in the system is the unit of the resultant quantity. For example, in any coherent system, unit area results when unit length is multiplied by unit length, unit velocity when unit length is divided by unit time, and unit force when unit mass is multiplied by unit acceleration.

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Historical note

The idea of a decimal system of units was conceived by Simon Stevin (1548–1620) who also developed the even more important concept of decimal fractions. Decimal units were also considered in the early days of the French Académie des Sciences founded in 1666, but the adoption of the metric system as a practical measure was part of the general increase in administrative activity in Europe which followed the French Revolution. Advised by the scientists of his day, the statesman Talleyrand aimed at the establishment of an international decimal system of weights and measures ' à tous les temps, à tous les peuples '. It was based on the metre as the unit of length (it was intended to be one ten-millionth part of the distance from the North Pole to the equator at sea level through Paris, but the circumstances did not permit this aim to be achieved with any great accuracy) and the gramme as the unit of quantity of matter. The gramme was to be the mass of one cubic centimetre of water at 0 °C.

Although the metric system was primarily devised as a benefit to industry and commerce, physicists soon realized its advantages and it was adopted also in scientific and technical circles. In 1873 the British Association for the Advancement of Science selected the centimetre and the gramme as basic units of length and mass for physical purposes.

Measurement of other quantities called for a base-unit of time and the adoption of the second for this purpose gave the centimetre-gramme-second system (c.g.s.). In about 1900 practical measurements in metric units began to be based on the metre, the kilogramme and the second (the MKS system). In 1935, the International Electrotechnical Commission (IEC) accepted the recommendation of Professor Giorgi that this system of units of mechanics should be linked with the electro-magnetic units by the adoption of any one of the latter as a fourth base-unit. The ampere, the unit of electrical current, was adopted by the IEC in 1950 as the fourth base-unit, giving the MKSA (or Giorgi) system.

Since 1875 all international matters concerning the metric system have been the responsibility of the Conférence Générale des Poids et Mesures (CGPM) which was constituted following the Convention held in Paris in that year. The CGPM meets in Paris, and controls the Comité International des Poids et Mesures (CIPM) and various Sub-committees as well as the Bureau International des Poids et Mesures (BIPM).

The laboratories of BIPM at Sèvres are the repository of the standard kilogramme and the former standard metre. The kilogramme is still defined in terms of the international prototype at Sèvres but the metre is now defined in terms of a number of wavelengths of a particular radiation of light. The United Kingdom participates in CGPM work, the Government department responsible being the Ministry of Technology.

At its tenth meeting, in 1954, the CGPM adopted a rationalized and coherent system of units based on the four MKSA units, the kelvin as the unit of tempera-

ture and the candela as the unit of luminous intensity. The eleventh CGPM in 1960 formally gave it the full title ' Système International d'Unités ' for which the abbreviation is ' SI ' in all languages.

The International System of Units (SI)

At Appendices A and B to this document there is reproduced an exposition of SI as it appears in the most recent ISO draft recommendation.

Attention is particularly drawn to the rules concerned with the formation of multiples and sub-multiples. These have as their object:

(1) Minimizing the variety of multiples and sub-multiples in common use.
(2) Ensuring that their presentation is uniform.
(3) Ensuring that their presentation is such that their relation to the coherent unit is always simple and obvious.

It will be seen in Appendix A that ' in order to avoid errors in calculations, it is essential to use coherent units '. Observance of the above mentioned rules will considerably facilitate the transition from data expressed in decimal multiples and sub-multiples to coherent units for the purpose of calculation. It is therefore recommended that unless compelling reasons to the contrary exist, the rules should be strictly observed.

Appendix B, taken from the annex to the ISO draft recommendation, lists the SI units and a selection of their recommended multiples and sub-multiples together with other units or other names of units which may be used. The appendix also includes some units which are not contained in the ISO draft recommendation but which may be used in the UK in addition to the internationally agreed selection. These are marked with an asterisk.

Units of mass, force and weight

The SI, being a coherent system of units, provides naturally for a coherent unit of force, namely the newton, and for the derivatives of that unit for quantities such as pressure, stress, work and power.

In practical work it has been a common practice to use weight units as force units; in other words, the unit of force used has been that force which applied to unit mass produces an acceleration g, rather than unit acceleration. This has several disadvantages:

(1) The value of gravitational acceleration g varies across the earth's surface and so the weight of a given mass also varies. Some years ago an attempt was made to correct this minor error by introducing the concept

of the kgf or lbf, which were defined as the forces due to 'standard gravity' acting on bodies of mass 1 kg or 1 lb respectively, standard gravitational acceleration being taken as 9·806 65 m/s² or 32·174 ft/s².

(2) g is 'built-in' to the definition of the gravitational unit force, and when this unit is used it gives rise to the following paradox in dynamics: that in those circumstances where the force of gravity plays a part, any mathematical expression will not contain g, whereas in circumstances where the force of gravity is not at all a factor, the related mathematical expressions must contain g to compensate for the fact that the unit of force used is g times greater than the coherent unit.

(3) The use of a mass unit sometimes, but not always, followed by the word 'force' or abbreviation 'f' in textual matter has often confused designers, who have been uncertain whether the mass unit implied a force or was meant as a pure mass.

There is thus a powerful case for the adoption of the coherent unit which obviates all of these disadvantages, being independent of g, and clear in statement.

Units of pressure and stress

The SI unit of pressure and stress is the newton per square metre. This unit and its recommended multiples and sub-multiples should normally be used.

Notwithstanding the general principles set out above, the bar and some of its decimal multiples and sub-multiples are used in certain fields and in particular have been adopted, on an interim basis, for the initial expression of metric values of stress or pressure in certain classes of British Standards. In all such standards and other publications the relationship between the adopted unit and the SI unit should be given as a footnote or other note on each relevant page of the text or table (e.g. 1 bar = 10^5 N/m², 1 hbar = 10^7 N/m², 1 mbar = 10^2 N/m²).

Details of such classes of British Standards are given below:

(1) In British Standards specifying in metric terms the strength of metallic materials, this property is expressed in hectobars.

(2) In British Standards specifying metric values of pressure relating to vessels, plant and equipment, this is expressed in bars, hectobars and millibars. However, in high vacuum work, for pressures of about 1 N/m² or less, the N/m² with its decimal sub-multiples is currently acceptable and is to be recommended in preference to the torr or mmHg.

Conversion from imperial to metric units

The UK will not gain the full advantages of adopting the metric system by a mere mathematical conversion of existing designs and products from, for instance, inches to the equivalent in millimetres. For Britain, the essence of the changeover operation is to line up with current international practice as a means of improving our competitiveness in oversea markets, the great majority of which are now metric. New designs will therefore have to be prepared on a metric basis, using customary metric sizes and metric components, and taking account of internationally agreed metric standards and the practice of the principal metric countries.

In a few cases where, for instance, interchangeability must be maintained, it may be necessary to carry out direct conversion from inch to metric dimensions. Part 1 of BS 350 ' Conversion factors and tables ', gives basic information on units and a summary of the conversion factors, including those for SI units. Detailed conversion tables are contained in Part 2, a supplement to which (Supplement No. 1) includes tables for SI units where they are not already given. Reference may also be usefully made to BS 2856 ' Precise conversion of inch and metric sizes on engineering drawings ', which recommends the conversion procedure giving the essential accuracy required for precise dimensional interchangeability.

Particulars of other British Standards concerned with units and conversion are given in Appendix E.

Appendix A

Rules for the use of units of the International System of Units

A.1 Scope. The purpose of this appendix is to give rules for the use of units of the International System of Units and for forming and selecting decimal multiples and sub-multiples of the SI units for application in the various fields of technology.

A.2 General

A.2.1 The name Système International d'Unités (International System of Units) and the international abbreviation SI are used for the systematically organized system of units introduced by the Conférence Générale des Poids et Mesures in 1960.

It includes the base-units of SI, supplementary SI units, derived SI units, and the decimal multiples and sub-multiples of these units, formed by use of prefixes.

The name ' SI units ' is reserved for the coherent units only.

A.2.2 The International System of Units is based on the following six base-units:

metre (m)	ampere (A)
kilogramme (kg)	kelvin (K)
second (s)	candela (cd)

as units for the basic quantities length, mass, time, electric current, thermodynamic temperature, and luminous intensity.

A.2.3 The SI units for plane angle and solid angle, the radian (rad) and the steradian (sr) respectively, are called supplementary units in the International System of Units.

A.2.4 The expressions for the derived SI units are stated in terms of base-units, for example the SI unit for velocity is metre per second (m/s).

For some of the derived SI units special names and symbols exist; those approved by the Conférence Générale des Poids et Mesures are listed below:

7

Quantity	Name of SI unit	Symbol	Expressed in terms of SI base-units or derived units
frequency	hertz	Hz	1 Hz = 1/s
force	newton	N	1 N = 1 kg m/s²
work, energy, quantity of heat	joule	J	1 J = 1 N m
power	watt	W	1 W = 1 J/s
quantity of electricity	coulomb	C	1 C = 1 A s
electric potential, potential difference, tension, electromotive force	volt	V	1 V = 1 W/A
electric capacitance	farad	F	1 F = 1 A s/V
electric resistance	ohm	Ω	1 Ω = 1 V/A
flux of magnetic induction, magnetic flux	weber	Wb	1 Wb = 1 V s
magnetic flux density, magnetic induction	tesla	T	1 T = 1 Wb/m²
inductance	henry	H	1 H = 1 V s/A
luminous flux	lumen	lm	1 lm = 1 cd sr
illumination	lux	lx	1 lx = 1 lm/m²

It may sometimes be advantageous to express derived units in terms of other derived units having special names, for example the SI unit of electric dipole moment (A s m) is usually expressed as C m.

A.2.5 Decimal multiples and sub-multiples of the SI units are formed by means of the prefixes given below:

Factor by which the unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

The symbol of a prefix is considered to be combined with the unit symbol to which it is directly attached, forming with it a new unit symbol which can be raised to a positive or negative power and which can be combined with other unit symbols to form symbols for compound units.

Examples

$$1\ \text{cm}^3 = (10^{-2}\ \text{m})^3 = 10^{-6}\ \text{m}^3$$
$$1\ \mu\text{s}^{-1} = (10^{-6}\ \text{s})^{-1} = 10^{6}\ \text{s}^{-1}$$
$$1\ \text{mm}^2/\text{s} = (10^{-3}\ \text{m})^2/\text{s} = 10^{-6}\ \text{m}^2/\text{s}$$

Compound prefixes should not be used, for example write nm (nanometre) instead of mμm.

A.3 Rules for the use of SI units and their decimal multiples and sub-multiples

A.3.1 The SI units are *preferred,* but it will not be practical to limit usage to these; in addition, therefore, their decimal multiples and sub-multiples, formed by using the prefixes, are required.

In order to avoid errors in calculations it is essential to use coherent units. Therefore, it is strongly recommended that in calculations only SI units themselves be used, and not their decimal multiples and sub-multiples.

A.3.2 The use of prefixes representing 10 raised to a power which is a multiple of 3 is especially recommended.

NOTE. In certain cases, to ensure convenience in the use of the units, this recommendation cannot be followed; Column 5 of the tables in Appendix B gives examples of these exceptions.

A.3.3 It is recommended that only one prefix be used in forming the decimal multiples or sub-multiples of a derived SI unit, and that this prefix be attached to a unit in the numerator.

NOTE. In certain cases convenience in the use requires attachment of a prefix to both the numerator and the denominator at the same time, and sometimes only to the denominator. Column 5 of the tables in Appendix B gives examples of these exceptions.

A.4 Numerical values

A.4.1 When expressing a quantity by a numerical value and a certain unit it has been found suitable in most applications to use units resulting in numerical values between 0·1 and 1000.

The units which are decimal multiples and sub-multiples of the SI units should therefore be chosen to provide values in this range, for example:

observed or calculated values	can be expressed as
12 000 N	12 kN
0·003 94 m	3·94 mm
14 010 N/m²	14·01 kN/m²
0·0003 s	0·3 ms

A.4.2 The rule according to A.4.1 cannot, however, be consistently applied. In one and the same context the numerical values expressed in a certain unit can

extend over a considerable range; this applies especially to tabulated numerical values. In such cases it is often appropriate to use the same unit, even when this means exceeding the preferred value range 0·1–1000.

A.5 List of units. Units for a number of commonly used quantities are given in Appendix B.

10

Appendix B

List of SI units and a selection of recommended decimal multiples and sub-multiples of the SI units together with other units or other names of units which may be used

An asterisk against a unit means that the unit may be used in the UK but is not yet included in the ISO draft recommendation.

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
Part I: Space and time						
1–1.1	plane angle	rad (radian)	mrad μrad		degree (. . . °), $1° = \frac{\pi}{180}$ rad minute (. . . ′), $1' = \frac{1°}{60}$ second (. . . ″), $1'' = \frac{1'}{60}$	
1–2.1	solid angle	sr (steradian)				
1–3.1 . . . 7	length	m (metre)	km mm μm nm	dm cm	*International nautical mile (1 n mile = 1852 m)	
1–4.1	area	m^2	km^2 mm^2	dm^2 cm^2	hectare (ha), 1 ha = 10^4 m^2 are (a), 1 a = 10^2 m^2	

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
1–5.1	volume	m^3		dm^3 cm^3	hectolitre (hl), $1\ hl = 10^{-1}\ m^3$ litre (l), $1\ l = 10^{-3}\ m^3 = 1\ dm^3$ centilitre (cl), $1\ cl = 10^{-5}\ m^3$ millilitre (ml), $1\ ml = 10^{-6}\ m^3 = 1\ cm^3$	In 1964 the Conférence Générale des Poids et Mesures adopted the name litre (l) as the synonym for cubic decimetre (dm^3) but discouraged the use of the name litre for precision measurements
			mm^3			
1–6.1	time	s (second)	ks ms µs ns		day (d), 1 d = 24 h hour (h), 1 h = 60 min minute (min), 1 min = 60 s	Other units such as week, month and year are in common use
1–8.1	angular velocity	rad/s				
1–10.1	velocity	m/s			kilometre per hour (km/h) $1\ km/h = \frac{1}{3{\cdot}6}\ m/s$ *knot (kn) 1 kn = 1 n mile/h = 0·514 444 m/s	
Part II: Periodic and related phenomena						
2–3.1	frequency	Hz (hertz)	THz GHz MHz kHz			

2–3.2	rotational frequency	1/s			revolution per minute (rev/min) revolution per second (rev/s)	
Part III: Mechanics						
3–1.1	mass	kg (kilogramme)	Mg g mg μg		tonne (t), 1 t = 10^3 kg	The metric carat (1 metric carat = 2×10^{-4} kg) is used for commercial transactions in diamonds, fine pearls and precious stones
3–2.1	density (mass density)	kg/m^3	Mg/m^3	1 kg/dm^3 = 1 g/cm^3	1 t/m^3 = 1 kg/l = 1 g/ml g/l	For litre (l) see item 1–5.1
3–5.1	momentum	kg m/s				
3–6.1	moment of momentum, angular momentum	$kg\ m^2/s$				
3–7.1	moment of inertia	$kg\ m^2$				
3–8.1	force	N (newton)	MN kN mN μN	daN		
3–10.1	moment of force	N m	MN m kN m μN m	daN m		

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiple of SI unit	Other units or other names of units which may be used	Remarks
3–11.1 3–11.2	pressure and stress	N/m^2	GN/m^2 MN/m^2 kN/m^2 mN/m^2 $\mu N/m^2$	daN/mm^2 N/mm^2 N/cm^2	1 hbar $= 10^7$ N/m^2 1 bar $= 10^5$ N/m^2 1 mbar $= 10^2$ N/m^2 1 μbar $= 10^{-1}$ N/m^2	The hectobar (hbar) is used in certain fields in some countries. The name ' pascal ' is given to the newton per square metre in certain countries
3–19.1	viscosity (dynamic)	N s/m²	mN s/m² *μN s/m²		centipoise (cP) 1 cP $= 10^{-3}$ N s/m²	
3–20.1	kinematic viscosity	m^2/s	mm^2/s		centistokes (cSt) 1 cSt $= 10^{-6}$ m^2/s	
3–21.1	surface tension	N/m	mN/m			
3–22.1	energy, work	J (joule)	GJ MJ kJ mJ		kilowatt hour (kW h) 1 kW h $= 3{\cdot}6 \times 10^6$ J $= 3{\cdot}6$ MJ electronvolt (eV) 1 eV $= (1{\cdot}602\,10 \pm 0{\cdot}000\,07) \times 10^{-19}$ J	The units W h, kW h, MW h, GW h and TW h are used in the electrical industry. The units keV, MeV and GeV are used in accelerator technology

3–23.1	power	W (watt)	GW MW kW mW μW			
	impact strength	J/m²	kJ/m²	daJ/cm² J/cm²		

Part IV: Heat

4–1.1	thermodynamic temperature	K (kelvin)				
4–2.1	Celsius temperature				degree Celsius (°C)	
4–1.1 4–2.1	temperature interval†	K			°C	1 °C = 1 K
4–3.1	linear expansion coefficient	1/K			1/°C	
4–4.1	heat, quantity of heat	J	TJ GJ MJ kJ mJ			
4–5.1	heat flow rate	W	kW			
4–6.1	density of heat flow rate	W/m²	MW/m² kW/m²			

† The abbreviation 'deg' is commonly used to express a temperature interval, but is now regarded as obsolescent by CGPM. However, it may be used in textual matter, e.g. 'Increase the temperature by 20 degC'.

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
4–7.1	thermal conductivity	W/m K			W/m °C	
4–8.1	coefficient of heat transfer	W/m² K			W/m² °C	
4–10.1	heat capacity	J/K	kJ/K		kJ/°C J/°C	
4–11.1	specific heat capacity	J/kg K	kJ/kg K		kJ/kg °C J/kg °C	
4–13.1	entropy	J/K	kJ/K			
4–14.1	specific entropy	J/kg K	kJ/kg K			
4–16.1	specific energy	J/kg	MJ/kg kJ/kg			
4–18.1	specific latent heat	J/kg	MJ/kg kJ/kg			
Part V: Electricity and magnetism (see Notes 1 and 2 on page 17)						
5–1.1	electric current (intensity of electric current)	A (ampere)	kA mA µA nA pA			

5–2.1	electric charge, quantity of electricity	C (coulomb)	kC μC nC pC			
5–3.1	volume density of charge, charge density	C/m³	MC/m³ kC/m³	C/mm³ C/cm³		
5–4.1	surface density of charge	C/m²	MC/m² kC/m²	C/mm² C/cm²		
5–5.1	electric field strength	V/m	MV/m kV/m mV/m μV/m	V/mm V/cm		
5–6.1 5–6.2 5–6.3	electric potential potential difference, tension electromotive force	V (volt)	MV kV mV μV			
5–7.1	displacement	C/m²	kC/m²	C/cm²		

NOTE 1. In electricity and magnetism the SI units assume the rationalized form of the equations between the quantities. See ISO/R 31, Part V.
NOTE 2. The IEC has not considered the rules given in Appendix A nor the arrangement and the content of the list. In order to give guidance to ISO, IEC/TC 24 provided the list of multiples and sub-multiples used here, but without division into columns.

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
5–9.1	electric flux, flux of displacement	C	MC kC mC			
5–11.1	capacitance	F (farad)	mF μF nF pF			
5–12.1	permittivity	F/m	μF/m mF/m pF/m			
5–17.2	electric polarization	C/m²	MC/m² kC/m²	C/cm²		
5–18.1	electric dipole moment	C m				
5–19.1	current density	A/m²	MA/m² kA/m²	A/mm² A/cm²		
5–20.1	linear current density	A/m	kA/m	A/mm A/cm		
5–21.1	magnetic field strength	A/m	kA/m	A/mm A/cm		

5–23.1	magnetic potential difference	A	kA mA			
5–24.1	magnetic flux density, magnetic induction	T (tesla)	mT μT nT			
5–25.1	flux of magnetic induction, magnetic flux	Wb (weber)	mWb			
5–26.1	magnetic vector potential	Wb/m	kWb/m	Wb/mm		
5–27.1 5–27.2	self inductance mutual inductance	H (henry)	mH μH nH pH			
5–29.1	permeability	H/m	μH/m nH/m			
5–34.1	electromagnetic moment, magnetic moment	A m²				
5–35.1	magnetization	A/m	kA/m	A/mm		
5–36.1	magnetic polarization	T	mT			
—	magnetic dipole moment	N m²/A Wb m				

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
5–41.1	resistance	Ω (ohm)	GΩ MΩ kΩ mΩ μΩ			
5–42.1	conductance	1/Ω			kS S (siemens) mS μS	1 S = 1/Ω the name ' siemens ' and the symbol ' S ' are adopted by IEC and ISO, but not so far by CGPM
5–43.1	resistivity	Ω m	GΩ m MΩ m kΩ m mΩ m μΩ m nΩ m	Ω cm		μΩ cm = 10^{-8} Ω m $\frac{\Omega\ mm^2}{m} = 10^{-6}\ \Omega\ m$ = μΩ m are also used
5–44.1	conductivity	1/Ω m			MS/m kS/m S/m *μS/m	
5–45.1	reluctance	1/H				
5–46.1	permeance	H				

5–49.1 5–49.2 5–49.3	impedance modulus of impedance reactance	Ω	MΩ kΩ mΩ			
5–51.1 5–51.2 5–51.3 5–51.4	admittance modulus of admittance susceptance conductance	1/Ω			kS S mS μS	
5–52.1	active power	W	TW GW MW kW mW μW nW			
5–53.1	apparent power	V A	*TV A *GV A *MV A *kV A *mV A *μV A *nV A			see also ISO/R 31/ Part V
5-54.1	reactive power				*Tvar *Gvar *Mvar *kvar *var *mvar *μvar *nvar	see also ISO/R 31/ Part V

21

Item No. in ISO/R 31	Quantity	SI unit	Selection of recommended decimal multiples and sub-multiples of SI unit	Other decimal multiples and sub-multiples of SI unit	Other units or other names of units which may be used	Remarks
Part VIII: Physical chemistry and molecular physics						
8–3.1	amount of substance				kmol mol†	
8–5.1	molar mass				kg/mol g/mol	
8–6.1	molar volume				m^3/mol m^3/kmol; l/mol	
8–7.1	molar internal energy				J/mol J/kmol	
8–8.1	molar heat capacity				J/mol K; J/mol °C J/kmol K; J/kmol °C	
8–9.1	molar entropy				J/mol K	
8–13.1	molarity				kmol/l kmol/m^3 mol/l mol/dm^3 mol/m^3	
8–15.1	molality				kmol/kg mol/kg	
8–36.1	diffusion coefficient	m^2/s				
8–38.1	thermal diffusion coefficient	m^2/s				

† In physical chemistry and molecular physics, the introduction of the additional unit the mole (mol), corresponding to the quantity ' amount of substance ', is recommended by IUPAP, IUPAC and ISO/TC 12. In this document the mole is not listed in Column 3 (SI unit) because it has not so far been approved by the CGPM.

1 mol is an amount of substance of a system which contains as many elementary units as there are carbon atoms in 0·012 kg of ^{12}C. The elementary unit must be specified and may be an atom, a molecule, an ion, an electron, etc., or a specified group of such particles.

Appendix C

Definitions of derived SI units with special names

force	The unit of force called the newton is that force which, when applied to a body having a mass of one kilogramme, gives it an acceleration of one metre per second squared.
energy	The unit of energy called the joule is the work done when the point of application of a force of one newton is displaced through a distance of one metre in the direction of the force.
power	The unit of power called the watt is equal to one joule per second.
electric charge	The unit of electric charge called the coulomb is the quantity of electricity transported in one second by a current of one ampere.
electric potential	The unit of electric potential called the volt is the difference of potential between two points of a conducting wire carrying a constant current of one ampere, when the power dissipated between these points is equal to one watt.
electric capacitance	The unit of electric capacitance called the farad is the capacitance of a capacitor between the plates of which there appears a difference of potential of one volt when it is charged by a quantity of electricity equal to one coulomb.
electric resistance	The unit of electric resistance called the ohm is the resistance between two points of a conductor when a constant difference of potential of one volt, applied between these two points, produces in this conductor a current of one ampere, this conductor not being the source of any electromotive force.
frequency	The unit of frequency called the hertz is the frequency of a periodic phenomenon of which the periodic time is one second.
magnetic flux	The unit of magnetic flux called the weber is the flux which, linking a circuit of one turn, produces in it an electromotive force of one volt as it is reduced to zero at a uniform rate in one second.

magnetic flux density	The unit of magnetic flux density called the tesla is the density of one weber of magnetic flux per square metre.
electric inductance	The unit of electric inductance called the henry is the inductance of a closed circuit in which an electromotive force of one volt is produced when the electric current in the circuit varies uniformly at the rate of one ampere per second.
temperature	The units of kelvin* and Celsius temperature interval are identical. A temperature expressed in degrees Celsius is equal to the temperature expressed in kelvin less 273·15†.
luminous flux	The unit of luminous flux called the lumen is the flux emitted within unit solid angle of one steradian‡ by a point source having a uniform intensity of one candela.
illumination	The unit of illumination called the lux is an illumination of one lumen per square metre.

* The name ' degree Kelvin ' (symbol °K) was changed to ' kelvin ' (symbol K) at the 13th CGPM (1967).

† This is true for the thermodynamic scale and for the international practical scale of 1968. There are, however, slight differences between thermodynamic scales and practical scales.

‡ One steradian is the solid angle which, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

Appendix D

Values of some imperial units in terms of SI units

Length

1 yd	**0·9144** m
1 ft	**304·8** mm
1 in	**25·4** mm
1 mile	**1·609 344** km

Area

1 in^2	**645·16** mm^2
1 ft^2	0·092 903 0 m^2
1 yd^2	0·836 127 m^2
1 $mile^2$	2·589 99 km^2

Volume

1 in^3	16 387·1 mm^3
1 ft^3	0·028 316 8 m^3
1 UKgal	4·546 09 dm^{3*}

Velocity

1 ft/s	**0·3048** m/s
1 mile/h	**0·447 04** m/s

Mass

1 lb	**0·453 592 37** kg

Density

1 lb/in^3	2·767 99 × 10^4 kg/m^3
1 lb/ft^3	16·0185 kg/m^3
1 lb/UKgal	0·099 776 3 Mg/m^3 (i.e. 0·099 776 3 kg/dm^{3*})

Force

1 pdl	0·138 255 N
1 lbf	4·448 22 N

Pressure

1 lbf/in^2	6·894 76 kN/m^2

Energy (work, heat)

1 ft pdl	0·042 140 1 J
1 ft lbf	1·355 82 J
1 cal†	**4·1868** J
1 Btu†	1·055 06 kJ

Power

1 hp	745·700 W

Temperature

1 Rankine unit (=1 Fahrenheit unit)	**5/9** of kelvin unit (=5/9 of Celsius unit)

Numbers printed in bold type are exact.

* By a resolution of the twelfth CGPM in 1964 the word ' litre ' (symbol l) is now recognized as a special name for the cubic decimetre, but is not used to express high precision measurements.

In 1901 the litre was defined as the volume of 1 kilogramme of pure water at normal atmospheric pressure and maximum density, equal therefore to 1·000 028 dm^3. This 1901 definition still applies for the purposes of the 1963 Weights and Measures Act. On the basis of the 1901 definition, 1 UKgal = 4·545 96 litres, but this small difference may be disregarded for most purposes.

† As defined by the 5th International Conference on Properties of Steam, London, 1956, and used by ISO. The calorie referred to is the international table calorie, cal_{IT}.

25

Appendix E

British Standards concerned with units and conversion of units

BS 350 : —— Conversion factors and tables.
Part 1 : 1959 Basis of tables. Conversion factors (*with Amendments* April and Oct. 1963, and Jan. 1965). 15s.
Part 2 : 1962 Detailed conversion tables. 25s.
Supplement No. 1. 1967 (PD 6203) Additional tables for SI conversions. 20s.

BS 1637 : 1950 Memorandum on the M.K.S. system of electrical and magnetic units. 3s.

BS 1957 : 1953 Presentation of numerical values (fineness of expression; rounding of numbers). 5s.

BS 1991 : —— Letter symbols, signs and abbreviations.
Part 1 : 1967 General. 15s.
Part 2 : 1961 Chemical engineering, nuclear science and applied chemistry. 10s.
Part 3 : 1961 Fluid mechanics. 7s. 6d.
Part 4 : 1961 Structures, materials and soil mechanics. 12s. 6d.
Part 5 : 1961 Applied thermodynamics. 7s. 6d.
Part 6 : 1963 Electrical science and engineering. 12s. 6d.

BS 2045 : 1965 Preferred numbers. 6s.

BS 2856 : 1957 Precise conversion of inch and metric sizes on engineering drawings (*with Amendment* Oct. 1965). 5s.

BS 2990 : 1958 Rationalized and unrationalized formulae in electrical engineering (*with Amendment* Jan. 1960). 5s.

BS 3763 : 1964 International System (SI) units. 8s.

Metric conversion slide (in plastics case). 21s.

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